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## CERTIFICATE

This certificate is issued in support of an application for Patent registration in a country outside New Zealand pursuant to the Patents Act 1953 and the Regulations thereunder.

I hereby certify that annexed is a true copy of the Provisional Specification as filed on 3 October 2003 with an application for Letters Patent number 528638 made by AgResearch Limited.

Dated 12 October 2004.



Neville Harris  
Commissioner of Patents, Trade Marks and Designs

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PATENTS ACT 1953  
PROVISIONAL SPECIFICATION

**RAPID SOIL DRYING**

We, AGRESEARCH LIMITED, a New Zealand Company of East Street, Ruakura Campus, Hamilton, New Zealand do hereby declare this invention to be described in the following statement:

## RAPID SOIL DRYING

### TECHNICAL FIELD

This invention is related to rapid soil drying. The present invention discloses a  
5 method and device that can be used prior to the measurement of chemical and physical properties within soil.

### BACKGROUND ART

Soil testing is a common occurrence for a variety of industries including farming. In farming, it is desirable to know the levels of various soil constituents such as 10 potassium, magnesium, sodium, calcium, phosphorus and sulphur so that, for example fertiliser is applied at correct concentration and frequency. Other testing applications include soil testing of constructions sites, industrial sites such as chemical processing facilities and mining sites, for example to determine if contamination has occurred from chemicals or heavy metals.

15 Current testing practice for determining key nutrient levels in soil is carried out in laboratories where samples are prepared for analysis. It is a standard to firstly prepare the soil sample via drying or moisture removal. By removing moisture from the soil sample, the sample becomes more stable and key constituents are less likely to alter over time. Changes that may occur include mineralisation of some 20 nutrients and soil pH changes. Traditionally, samples are dried to a point where there is minimal residual moisture – i.e. if the sample was re-dried, there would be no detectable loss in weight.

At present, soil cores are collected in the field and then transported to laboratories where they are kept intact and dried overnight (for at least 20 hours) at

temperatures of 30 –35 °C. The following day the samples are ground and passed through a 2mm sieve, at which point the samples are then ready for chemical or physical analysis.

Alternative methods of drying such as freeze drying and microwave drying are not generally used in standard laboratory testing. Both of these alternative methods are comparatively expensive and require specialised equipment.

The soil cores are intact plugs of soil approximately 2.5 x 7.5 cm (agricultural) and 2.5 x 15 cm (horticultural) which are used to determine the nutrient status. The recommendation is that 15 – 20 cores are taken of the area where the nutrient status of the soil is desired.

A key drawback of the above standard soil preparation practice is that at least one day is lost before chemical analysis can commence.

A further disadvantage of present practice is that samples must be transported to a remote site i.e. the laboratory. Besides the extra cost of transport, this additional step introduces possible contamination of the samples e.g. through mishandling of the samples or exposure to heat or moisture during transportation.

It is therefore highly advantageous if soils can be dried rapidly, without compromising chemical and physical test results so that test results can be obtained more quickly.

It is an object of the present invention to address the foregoing problems or at least to provide the public with a useful choice.

All references, including any patents or patent applications cited in this specification are hereby incorporated by reference. No admission is made that any reference constitutes prior art. The discussion of the references states what their authors

assert, and the applicants reserve the right to challenge the accuracy and pertinency of the cited documents. It will be clearly understood that, although a number of prior art publications are referred to herein, this reference does not constitute an admission that any of these documents form part of the common general knowledge in the art, in New Zealand or in any other country.

It is acknowledged that the term 'comprise' may, under varying jurisdictions, be attributed with either an exclusive or an inclusive meaning. For the purpose of this specification, and unless otherwise noted, the term 'comprise' shall have an inclusive meaning - i.e. that it will be taken to mean an inclusion of not only the listed components it directly references, but also other non-specified components or elements. This rationale will also be used when the term 'comprised' or 'comprising' is used in relation to one or more steps in a method or process.

Further aspects and advantages of the present invention will become apparent from the ensuing description which is given by way of example only.

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#### DISCLOSURE OF INVENTION

- According to one aspect of the present invention there is provided a method for drying soil including the steps of:
- (a) increasing the surface area of the soil;
  - 20 (b) forcing a substantially inert gas through the soil;
  - (c) subjecting the soil to an elevated temperature.

The present invention relates to a method of drying soil in a manner that removes moisture from the soil, whilst also substantially not altering chemical and/or physical

characteristics of the soil, other than removal of moisture (water).

In one embodiment, steps (a) to (c) as described above may be performed sequentially. In alternate embodiments, steps (a) and (b), (b) and (c), (a) and (c), or (a), (b) and (c) may be performed at substantially the same time.

- 5      In preferred embodiments, the speed of drying may be substantially more rapid when compared to prior art methods (i.e. less than 24 hours). It has been found by the inventor that the speed of drying may be reduced to less than substantially one hour. More preferably, the speed for drying may be less than substantially 20 minutes. Those skilled in the art should appreciate that the rate of drying may be dependent on the soil type. It is the inventor's experience that clay soils tend to take the longest to dry whereas sandy soils are by comparison, quicker to dry.
- 10
- 15

The present invention can be used in relation to soils taken from a wide variety of sites. In preferred embodiments, the soil may be a sample taken from arable land. In other embodiments, soil may be taken from construction sites, forestry sites, or industrial manufacturing facilities. This list should not however be seen as limiting.

It should be appreciated by those skilled in the art that the drying method may be performed at the test site (in-situ) or in a laboratory or other testing facility.

- It is envisaged that the present invention is robust enough that it may be used for all varieties of soil types. The fact that the present invention removes moisture rapidly from the sample without substantially altering the chemical and/or physical characteristics of the soil is a critical factor in laboratory analysis where the sample, when measured, must still be representative of the area from which the sample was taken. Characteristics of particular note that the soil sample should remain representative of, with respect to the site where the sample was taken, may include the level of phosphorus (or Olsen P), sulphur, heavy metals, potassium,
- 20
- 25

magnesium, sodium and calcium and other elements or compounds that are routinely required to be analysed. Further characteristics in relation which the sample should remain representative of the original site, include the degree of elasticity of the soil sample or friability / texture properties of the soil generally.

- 5 Preferably, the increase in surface area may be achieved by breaking the soil down into smaller particles by mechanical motion, for example by hand, or in a machine, by pressing the soil through a sieve. Most preferably the mean particle size may be substantially less than 10mm, although it should be appreciated that the soil need not be of a uniform particle size. It is the inventor's experience that a reduced 10 particle size increases the speed with which moisture is removed from the soil particles.

In preferred embodiments, the inert gas may be air. Most preferably, the gas may be moisture free. In alternative embodiments, the method may include gas conditioners such as a dehumidifier step and/or use of a desiccating gel to remove 15 moisture from the gas prior or during use in the present invention. Those skilled in the art should appreciate that the use of dry air mimics the effect of wind drying.

Preferably, gas may be forced across the soil particles. In general, the air is fan forced. Most preferably the gas velocity may be less than 4 m/s. Most preferably, the velocity may be approximately 2 m/s.

- 20 Preferably, the temperature to which the soil may be elevated is high enough to allow sample drying without impacting on the chemical and/or physical properties of the soil, apart from moisture reduction. In the inventor's experience this temperature may be critical and preferably, the temperature range varies from approximately 20°C to 50°C, although lower temperatures are also envisaged. It is 25 likely that temperatures above approximately 50°C result in not only moisture loss, but also deterioration of the chemical and/or physical structure of the soil. In

preferred embodiments, the temperature to which the soil may be elevated varies from approximately 30°C to 40°C. Most preferably the temperature may be substantially 35°C.

In a further embodiment, the drying equipment may be preheated before step (c).

- 5 In an alternative embodiment, the method may also include a further step (d) of:

- (d) keeping the soil in motion.

Preferably, the particles remain in motion for substantially all of the drying time. In an alternative embodiment, particles may only be kept in motion for a discrete portion of time and/or discrete portions of time.

- 10 Methods envisaged by the inventor for keeping the soil in motion may include tossing, vibration, oscillation or shaking the soil in a dish or in a container or containers such as a container or series of containers, either in series or nested within each other

- According to a further aspect of the present invention there is provided an  
15 assembly for drying of soil which includes:

- (a) an inert gas supply device which is capable of forcing inert gas through the soil;

- (b) a heating element which is capable of subjecting the soil to an elevated temperature.

- 20 Preferably the assembly described above further includes a soil crusher device which is capable of increasing the surface area of the soil.

Preferably the assembly described above further includes a device capable of keeping the soil in motion.

According to a further aspect of the present invention there is present the use of a method and/or device substantially has described above for the removal of moisture from a soil sample.

From the above description, those skilled in the art should appreciate that the 5 invention offers a fast alternative to present soil drying methods that allows for faster testing of soil samples. The method includes the steps of increasing particle surface area, forced air circulation and elevated temperature. A device is also described which incorporates the above steps. As the process is quick and the 10 device simple, measurements can be made in situ to avoid complications of transporting the sample to a laboratory.

#### **BRIEF DESCRIPTION OF DRAWINGS**

Further aspects of the present invention will become apparent from the following 15 description which is given by way of example only and with reference to the accompanying drawings in which:

Figure 1 is a drawing of a soil core sample;

Figure 2 is a drawing of soil core samples on a sieve; and,

Figure 3 is a drawing of a sub-sample from the core samples.

#### **20 BEST MODES FOR CARRYING OUT THE INVENTION**

Non-limiting examples illustrating the invention will now be provided. It will be appreciated that the below description is provided by way of example only and variations in materials and technique used which are known to those skilled in the

art are contemplated.

In order to determine if there may be a difference in key nutrient results, tests were completed where soils were dried at differing rates. Soil core samples are currently dried at 30-35°C overnight (20 – 24 hours) and control samples using this method  
5 of drying were used for comparison.

Soils encompassing many soil groups were collected for analysis. These soils were sieved and mixed thoroughly.

**Example 1:**

- 10 Referring to Figure 1, core samples 1 of granular soil (clay loam) were received (soil samples 1A and 1B as shown in the table below) and placed into a 2 mm sieve 2 as shown in Figure 2. The soil core samples were broken down and forced through the sieve to reduce the particle surface area. A sub-sample 3 (labelled 1B) was then taken as shown in Figure 3 which was then placed into a soil dryer of the 15 present invention (not shown) and dried at 35°C, with air flow and particle motion for 20 minutes. A further sub-sample (1A) was taken and placed into a traditional dryer and dried overnight at 35° as per standard technique. Further samples 1C and 1D were also taken and dried at 48°C, with air flow and particle motion for 20 minutes and 15 minutes respectively.
- 20 Before drying, the moisture content of each sample was measured as having a moisture content of 32.1% wt.

After the times defined above, the samples were measured for phosphorus levels (Olsen P). Phosphorus tests were chosen as phosphorus this is a very important agronomical test for pastoral farming as phosphate fertiliser incurs the majority of

the cost of fertilisation, particularly in New Zealand farming.

The moisture content after drying in the case of sample 1A, the traditional method, was 0.0%wt. For samples 1B, 1C and 1D, the residual moisture contents were 2.2%wt, 0.2%wt and 0.0%wt respectively.

- 5 Olsen phosphorus (P) levels after drying were measured in duplicate and shown in **Table 1** below.

**Table 1:** Olsen P Levels Example 1

Soil Sample	Olsen P – Test 1	Olsen P – Test 2
1A	45	45
1B	45	46
1C	51	54
1D	47	50

10 **Example 2:**

- The same soil type as Example 1 was tested using different samples and the same method as described in Example 1 with soil samples 1 labelled 2A (traditional drying at 35°C overnight), 2B (35°C, with air flow and particle motion for 20 minutes) and 2C and 2D (48°C, with air flow and particle motion for 20 and 15 minutes respectively).

Before drying, the moisture content of each sample was measured as having a moisture content of 31.1% wt.

The moisture content after drying in the case of sample 2A, the traditional method, was 0.0%wt. For samples 2B, 2C and 2D, the residual moisture content was 3.7%wt, 0.0%wt and 0.2%wt respectively.

- Olsen phosphorus (P) levels after drying were measured in duplicate and shown in  
 5 **Table 2** below.

**Table 2:** Olsen P Levels Example 2

Soil Sample	Olsen P – Test 1	Olsen P – Test 2
2A	20	22
2B	20	21
2C	23	22
2D	23	24

**Example 3:**

- 10 The same soil type as Example 1 was tested using different samples and the same method as described in Example 1 with soil samples 1 labelled 3A (traditional drying at 35°C overnight), 3B (35°C, with air flow and particle motion for 20 minutes), and 3C and 3D (48°C, with air flow and particle motion for 20 and 15 minutes respectively).
- 15 Before drying, the moisture content of each sample was measured as having a moisture content of 31.1% wt.

The moisture content after drying in the case of sample 2A, the traditional method, was 0.0%wt. For samples 3B, 3C and 3D, the residual moisture content was

7.4%wt, 0.4%wt and 2.4%wt respectively.

Olsen phosphorus (P) levels after drying were measured in duplicate and shown in

**Table 3** below.

5   **Table 3: Olsen P Levels Example 3**

Soil Sample	Olsen P – Test 1	Olsen P – Test 2
3A	25	25
3B	25	28
3C	33	34
3D	35	36

**Example 4:**

Different soil types were tested, gley soil (silt loam), using the same method as described in Example 1 with soil samples 1 labelled 4A (traditional drying at 35°C overnight), 4B (35°C, with air flow and particle motion for 20 minutes) , and 4C and 4D (48°C, with air flow and particle motion for 20 and 15 minutes respectively)..

Before drying, the moisture content of each sample was measured as having a moisture content of 39.5% wt.

The moisture content after drying in the case of sample 4A, the traditional method, was 0.0%wt. For samples 4B, 4C and 4D, the residual moisture content was 8.9%wt, 0.2%wt and 2.8%wt respectively.

Olsen phosphorus (P) levels after drying were measured in duplicate and shown in

**Table 4** below.**Table 4: Olsen P Levels Example 4**

Soil Sample	Olsen P – Test 1	Olsen P – Test 2
4A	13	13
4B	12	12
4C	14	15
4D	14	13

**5 Example 5:**

Different soil types were tested, allophanic soil (sandy loam) using the same method as described in Example 1 with soil samples labelled 5A (traditional drying at 35°C overnight), 5B (35°C, with air flow and particle motion for 20 minutes) and 5C and 5D (48°C, with air flow and particle motion for 20 and 15 minutes

10 respectively).

Before drying, the moisture content of each sample was measured as having a moisture content of 30.9% wt.

The moisture content after drying in the case of sample 5A, the traditional method, was 0.0%wt. For samples 5B, 5C and 5D, the residual moisture content was 15 5.0%wt, 0.0%wt and 0.4%wt respectively.

Olsen phosphorus (P) levels after drying were measured in duplicate and shown in **Table 5** below.

**Table 5: Olsen P Levels Example 5**

Soil Sample	Olsen P – Test 1	Olsen P – Test 2
5A	17	18
5B	17	17
5C	21	21
5D	21	25

The above examples showed that the two methods of preparation compared well  
 5 with a statistical analysis showing no significant difference in Olsen P levels using either traditional methods of preparation or rapid drying at 35°C. A variation of up to 16% was noted for rapid drying at 48°C.

The above examples show that the method and device of the present invention may allow soil to be dried faster than conventional methods with a similar degree of accuracy in measurement of chemical and physical characteristics, however taking 10 less time for sample preparation than traditional methods.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof.

15

AGRESEARCH LIMITED

by their Attorneys

**JAMES & WELLS***R.M. Jackson*

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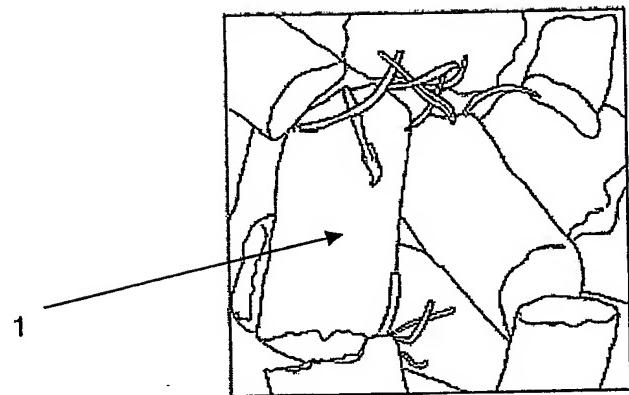


Figure 1

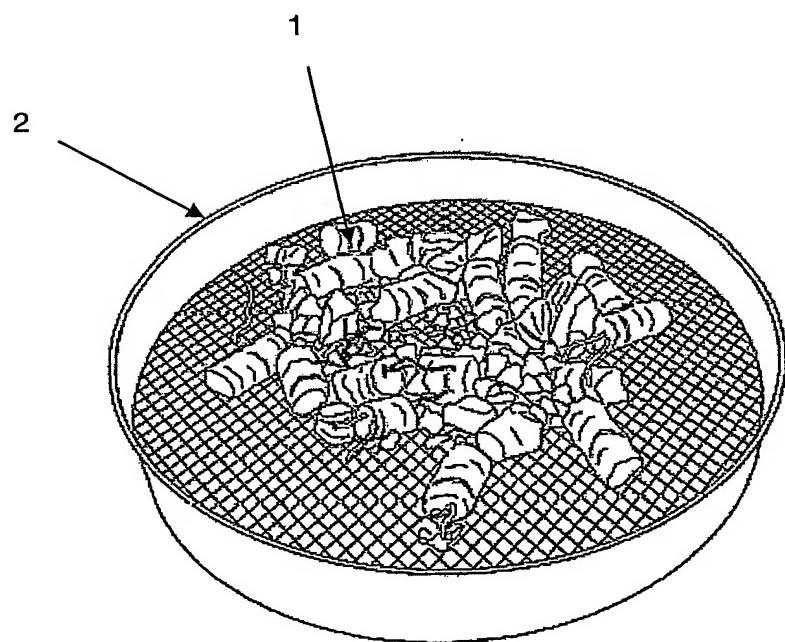


Figure 2

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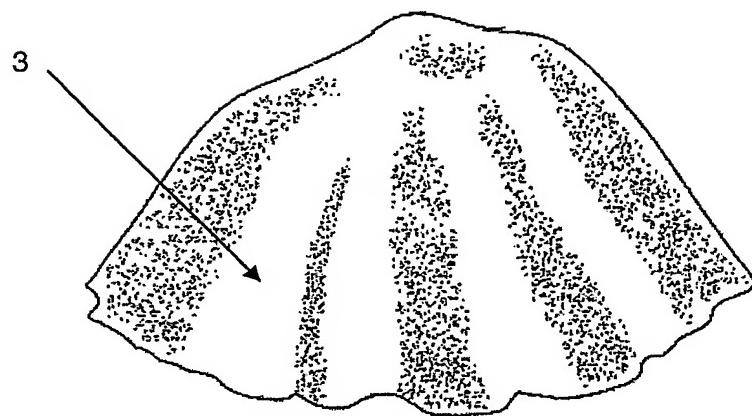


Figure 3

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